THE AZOREAN BLACKSPOT SEABREAM, *PAGELLUS BOGARAVEO* (BRÜNNICH, 1768) (TELEOSTEI : SPARIDAE) : AGE AND GROWTH

by

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ABSTRACT. - Otoliths were used to determine the age and growth of the blackspot seabream *Pagellus bogaraveo* (Brünnich, 1768) in Azorean waters. The occurrence of annuli on the otoliths was confirmed. The growth rate was estimated by direct reading and by backcalculation. Maximum age of fish collected was 15 years and the von Bertalanffy equation of growth in length was : $L = 57.45\ (1 - e^{-0.102\ (t+1.13)})$. The length-weight relationship was : $W = 0.0124\ L^{3.137}$.

RÉSUMÉ. - L'âge et la croissance de la dorade rose, *Pagellus bogaraveo* (Brünnich, 1768) aux Azores ont été déterminés par comptage des annuli sur les otolithes. La vitesse de croissance a été estimée par lecture directe des otolithes et aussi par rétrocalcul. L'âge maximal des poissons échantillonnés est de 15 ans. L'équation de von Bertalanffy pour la croissance en longueur est : $L = 57.45^{(1-e\ -0.102\ (t+1.13)}$ et la relation taille-poids du corps est : $W = 0.0124\ L^{3.137}$.

Key-words : Sparidae, *Pagellus bogaraveo*, ANE, Azores, Age determination, Otolith reading, Growth.

Pagellus bogaraveo is a demersal fish common in western Mediterranean, absent or very rare in eastern Mediterranean beyond the Sicilian Strait ; some records in Adriatic, absent in Black Sea ; occurring in the northeastern Atlantic from Norway (65°N) to Cape Blanc, Madeira and Canary Islands, exceptionally farther south (Bauchot *et al.*, 1986). In Azorean waters this is a very common species. The depth range goes from inshore waters (young fish) to about 700 m. Longline and handline represent the most important fisheries for this species catches. From a commercial point of view, blackspot seabream is the most important demersal species occurring in Azorean waters. Its local name is «goraz» for the adults, «peixão» for the pre-adults and «carapau» for the juveniles.

Informations on age and growth of blackspot seabream from the Cantabrian Sea, French and Marrocco waters were published by Olivier (1928), Coupé (1954), Ramos *et al.* (1967), Gueguen (1969) and Sanchez (1983). From the Azores, a preliminary study was carried out by Krug (1983).

The objective of the present study was to describe the growth of *P. bogaraveo* in Azorean waters including (1) periods of annulus formation in the otolith, (2) growth in length, (3) fish length otolith radius relationship, and (4) growth in weight.

MATERIAL AND METHODS

Fish samples were obtained from catches in Azorean waters from September 1982 to July 1984. Fish were caught monthly by the research vessels «Geralda» or «Noruega» or by commercial fishing boats, using longlines and handlines. The total and fork lengths were measured to the nearest cm below, and fish were weigthed to the nearest 0.1g. Then, they were dissected and their sexes macroscopically determined (males, females, hermaphrodites and juveniles).

Sagitta otoliths were extracted, cleaned, dried and stored in paper envelopes. For age reading, they were immersed in alcohol and observed using a binocular microscope (magnifi-

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cation x 10) with transmitted light. The otolith radius in the longest otolith axis and the corresponding radius of each annulus (the distance from the nucleus to the beginning of each opaque zone) were measured using an ocular micrometer (Fig. 1).

RESULTS

Fork length-total length relationship

Because of the long exsertions, the caudal fin was often worn or broken. Therefore, both total and fork lengths were recorded in 400 specimens, the latter measurement being the more reliable.

The relationship used to convert measurements of total length (TL) to fork length (FL) is :

$$FL = 0.8984\ TL - 0.4634 \quad r^2 = 0.996 \qquad (1)$$

and vice-versa :

$$TL = 1.1324\ FL - 0.0429 \quad r^2 = 0.998 \qquad (2)$$

Period of annulus formation

Rings on otoliths were determined to be annuli by analysing marginal increments. The period of annulus formation was found from seasonal variations in the nature of the edge of 672 otoliths from specimens with size ranged from 6 to 51 cm. The relative distribution (%) of opaque and hyaline edges in each month, from January to December 1983, is shown (Fig. 2). Opaque edges were found from March to November, they were, however, dominant from June to October. This confirms the annual periodicity of the growth zone formation.

Growth in length

Direct method : By direct reading of the otoliths, the age-length key was done (Table I) and the mean lengths of each age group were estimated (Table II and Fig. 3). From these von Bertalanffy growth parameters were estimated using the program VONBER from Allen (Sims, 1985) (Table III). The von Bertalanffy equation of growth in length was :

$$L = 58.50\,(1 - e^{-0.117\,(t+1.55)}) \qquad (3)$$

Backcalculation of growth : Fish length-otolith radius relationship (L/OR) was estimated from 659 specimens and is given by the equation (Fig. 4) :

$$L = 39.4177\ OR^{1.189} \quad r^2 = 0.9801 \qquad (4)$$

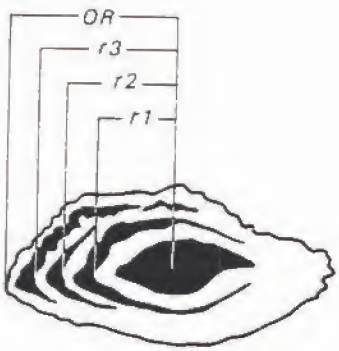

Fig. 1 : Otolith measurements in *P. bogaraveo*. OR - otolith radius ; r1, r2 and r3 - radius of annulus 1, 2 and 3.

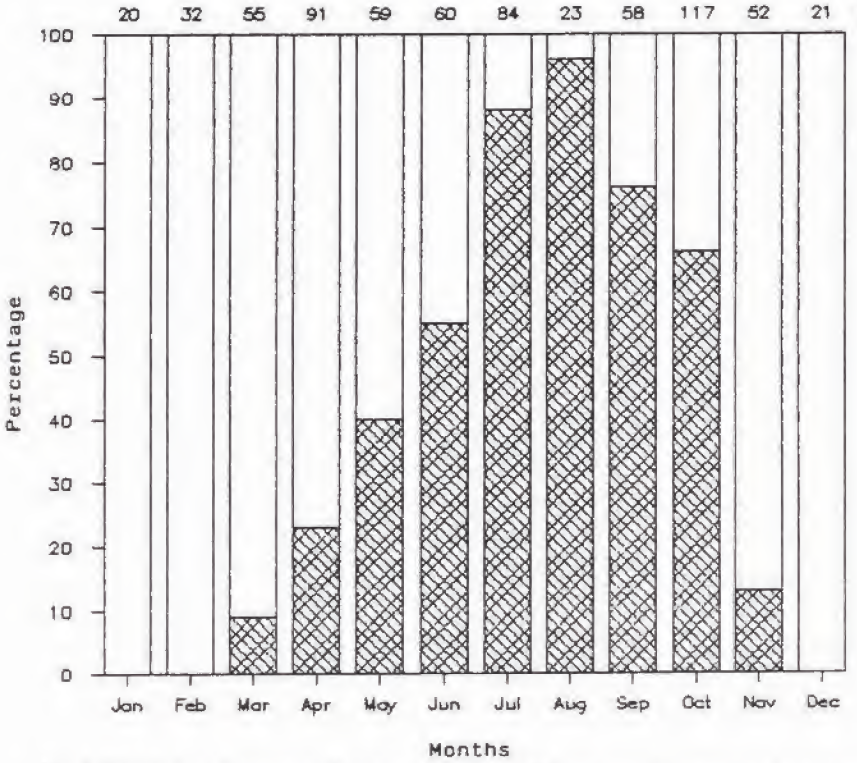

Fig. 2 : Distribution of opaque and hyaline otolith edges in *P. bogaraveo*. N = number of otoliths.

similarly

$$L' = 39.4177\ rn^{1.189} \tag{5}$$

where rn is the distance of each annulus to the nucleus and L' is the corresponding length. By the Dahl-Lea method (Le Cren, 1947) of direct proportionality between otolith radius and fish length, the length of the fish is backcalculated by the formula :

$$L' = \frac{Lrn}{OR} \tag{6}$$

but by equations 4 and 5 this should become :

$$L' = L\left(\frac{rn}{OR}\right)^{1.189} \tag{7}$$

and can be expressed in a logarithmic form :

$$\log L' = \log L + 1.189\,(\log rn - \log OR) \tag{8}$$

The backcalculated lengths for allometric growth are summarized in Table IV. The Rosa Lee's phenomenon is not very clear.

Based on these lengths, von Bertalanffy growth parameters were calculated (Table III). The equation of growth in length becomes :

$$L = 57.45\ (1 - e^{-0.102\ (t + 1.13)}) \qquad (9)$$

The observed and calculated values are shown in Fig. 3.

Growth in weight

872 specimens were used to calculate the relationship between length and weight for each sex. The functional regression (Ricker, 1973) : $\log W = u + v \log L$, where W is weight in grams and L is the fish length in cm, was used.

The analysis of covariance and multiple comparisons among the slopes by a Newman-Keules test (Zar, 1974) showed that hermaphrodites versus females and males versus juveniles have similar slopes (Table V). The correlation-coefficient (r) shows a high degree of homogeneity in the samples. Males and juveniles were slightly heavier than females and hermaphrodites of the same length. A common functional regression is more useful for practical purposes :

Table I : Fork length (FL) distributions of the age groups of *P. bogaraveo*. N = number of fish.

FL	Age groups															
cm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	N
53													1	1		2
52												1		1		2
51												1				1
50											1		1			2
49															1	1
48											1	1	2	1		5
47									1		1	2	1			5
46										4	2	2	1			9
45									1	2	6					9
44								1	2	3	1		1	1		9
43									2	8	3	2	2			17
42								2	6	2		2	1			13
41							2	7	6	5	1	1				22
40						1	1	9	3	1	1					16
39						1	5	8	4	2						20
38						3	8	7	2	2						22
37						6	11	8	1							26
36					1	10	9	3	2							25
35					1	10	7	2								20
34					2	12	3	1								18
33					3	8										11
32				3	8	4										15
31				6	11	1										18
30				5	20	1										26
29			2	15	14											31
28			2	26	10											38
27			5	24	3											32
26			17	25	3											45
25		1	23	19												43
24		3	13	5												21
23		1	23													24
22		9	17													26
21		8	14													22
20		11	9													20
19		13	2													15
18	1	11														12
17		9														9
16	2	1														3
15	1	1														2
14																0
13	1															1
12	1															1
N	6	68	127	128	76	57	46	48	30	29	17	12	10	4	1	659

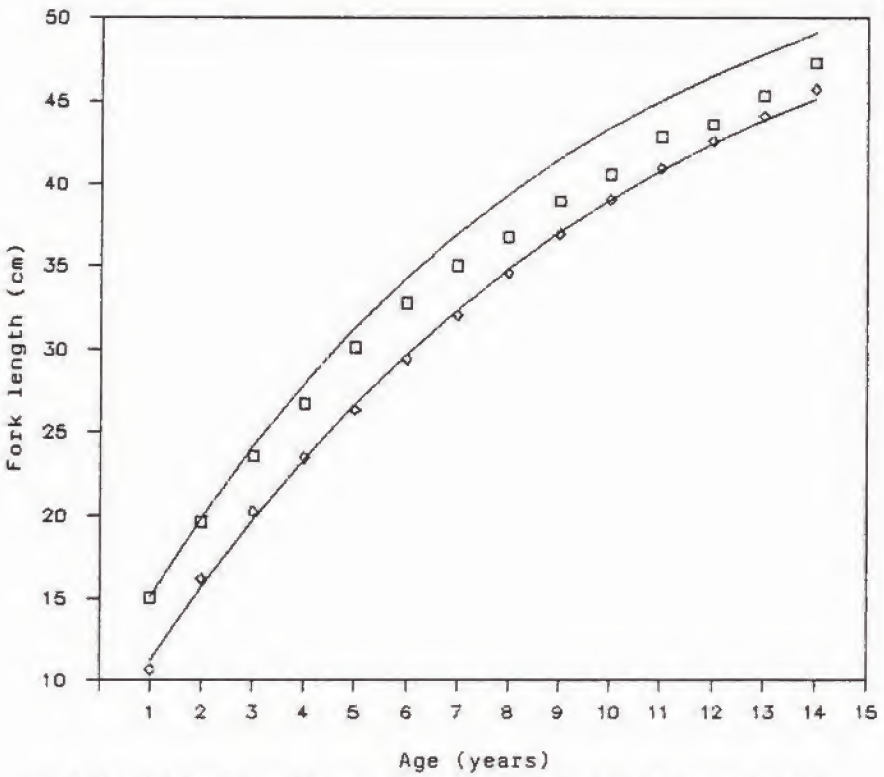

Fig. 3 : Growth in length by otolith reading (squares) and by backcalculation (lozenges) methods.

Table II : Growth in length (FL) of *P. bogaraveo* determined by otolith reading. (*) = von Bertalanffly equation.

Age group	N	FL observed	95 % conf. limits	FL (*) calculated
1	6	15.00	12.70 - 17.30	15.09
2	68	19.63	19.20 - 20.14	19.88
3	127	23.59	23.21 - 23.97	24.15
4	128	26.73	26.38- 27.08	27.94
5	76	30.08	29.64 - 30.52	31.31
6	57	32.74	32.19 - 33.29	34.32
7	46	34.96	34.45 - 35.47	36.99
8	48	36.71	36.11 - 37.31	39.36
9	30	38.90	37.99 - 39.81	41.48
10	29	40.52	39.53 - 41.41	43.35
11	17	42.82	41.57 - 44.07	45.03
12	12	43.58	41.24 - 45.92	46.51
13	10	45.30	42.67 - 47.43	47.84
14	4	47.25	40.71 - 53.74	49.02

(*) von Bertalanffy equation

$$\log W = 3.1373 \log L - 1.9063 \qquad r^2 = 1.00 \tag{10}$$

95 % conf. limits of v were : $3.1002 < v < 3.1744$ (n = 872)
so,

$$W = 0.0124\ L^{3.1373} \tag{11}$$

Fig. 4 : Relationship between fork length (FL) (mm) and otolith radius (OR) (mm) for *P. bogaraveo*. The squares represent the mean otolith radius for every 10 units (mm) of fork length.

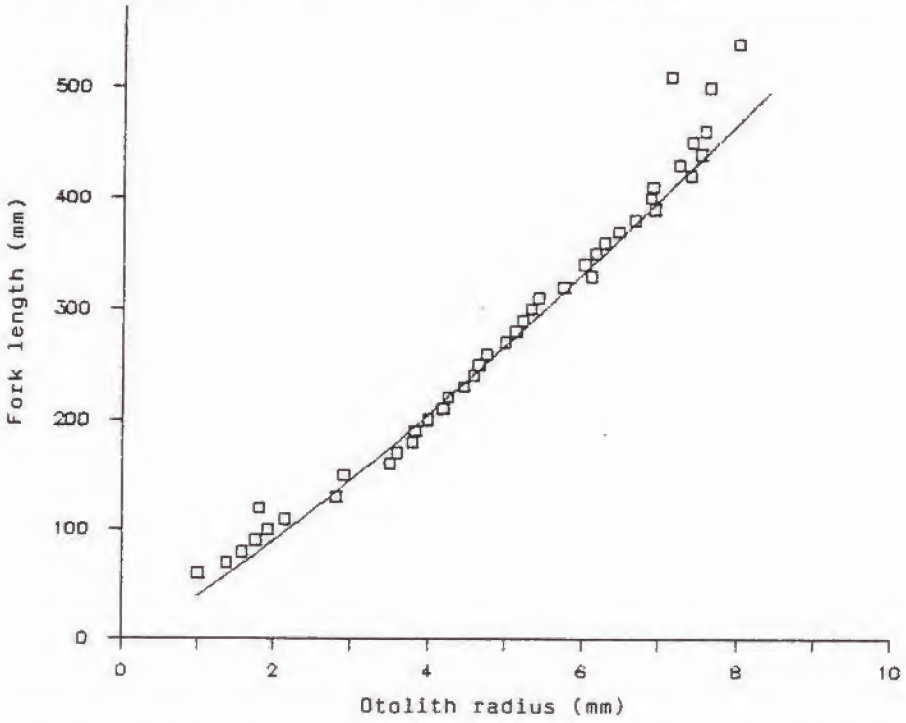

Table III : Estimated growth parameters (L_∞, K, to) with their 95 % confidence limits for the lengths obtained by direct method and by backcalculation.

	Direct method		Indirect method	
	Final estimate	95 % conf. limits	Final estimate	95 % conf. limits
L_∞	58.49722	55.40593-61.58851	57.45379	54.69012-60.21747
K	0.116611	0.101784-0.131439	0.101807	0.920640-0.111550
to	- 1.55437	-1.84657-(-1.26216)	-1.12973	-1.28195-(-0.97751)

By direct method, the von Bertalanffy equation of growth in weight was :

$$W = 4339.7\ (1 - e^{-0.117\ (t + 1.55)})^{3.1373} \qquad (12)$$

By backcalculation, the equation was :

$$W = 4101.4\ (1 - e^{-0.102\ (t + 1.13)})^{3.1373} \qquad (13)$$

The observed and calculated weight values for each of the above referred methods are shown in Table VI.

Table IV : Backcalculated fork length (cm) at the end of each year of life. (*) = von Bertalanffly equation.

Age groups	N	Mean calculated fork length at the end of each year of life													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	10.20													
2	68	9.39	16.03												
3	127	10.21	16.11	20.51											
4	128	10.54	16.08	20.89	23.97										
5	72	10.62	16.14	20.53	24.46	27.91									
6	41	10.60	15.61	20.03	23.99	27.48	30.64								
7	21	10.66	15.41	20.61	24.05	27.07	30.00	32.79							
8	20	10.50	15.87	19.72	23.14	26.33	29.26	31.97	34.79						
9	18	9.74	15.60	19.40	21.73	24.10	28.33	31.42	34.56	36.46					
10	13	11.30	16.90	20.24	23.86	26.81	29.45	33.14	35.53	38.34	39.79				
11	11	11.24	16.66	20.32	23.64	26.46	29.46	32.11	34.38	37.10	39.15	41.43			
12	9	11.60	16.96	20.27	22.87	25.92	28.76	31.64	34.57	36.97	38.96	40.97	42.56		
13	5	11.53	16.25	19.64	22.72	24.73	28.34	32.01	34.63	36.77	38.93	40.89	42.57	44.04	
14	3	10.97	16.97	20.82	24.31	26.44	30.56	31.51	33.45	35.74	38.23	40.28	42.51	44.13	45.69
observed. FL		10.65	16.20	20.25	23.52	26.33	29.42	32.07	34.56	36.90	39.01	40.89	42.55	44.09	45.69
95 % conf. limits		10.28 11.02	15.88 16.52	19.95 20.55	22.98 24.06	25.51 27.15	28.77 30.07	31.57 32.57	34.01 35.11	36.04 37.76	38.37 39.65*	40.24 41.54	42.49 42.61	43.91 44.27	
calc. FL (*)		11.22	15.70	19.75	23.41	26.71	29.69	32.38	34.81	37.01	38.99	40.78	42.40	43.86	45.17

(*) von Bertalanffy equation

Table V : Parameters (u and v) of the equation for the relationship between length and weight for each sex.

Sex	N	u	v	95 % conf. limits (v)	r^2
Females	227	1.8463	3.0938	3.0365-3.1311	0.98
Hermaphrodites	184	1.8270	3.0926	3.0693-3.1149	0.99
Males	235	1.9668	3.1735	3.1432-3.2038	0.99
Juveniles	226	2.0440	3.2512	3.1696-3.3280	1.00

DISCUSSION

The formation of a single opaque ring throughout the year, as observed in Fig. 2, indicates that otolith age reading is a valid method for studying the growth of this species.

The fish length-otolith radius relationship was allometric and positive (b = 1.189, b>1) (Fig. 4). The body-scale relationship of *P. bogaraveo* in Bay of Biscay studied by Gueguen (1969) was also allometric.

If the backcalculated lengths-at-age are compared with those obtained from direct reading it can be seen that there is relative coincidence between them. In this comparison two aspects should be pointed out. The backcalculated lengths correspond to the real age of the fish, while those obtained by direct reading correspond to the age group ; and the mean length of the first two age groups are over-estimated, due to the selective fishing mortality. So, it was considered to be more reliable to establish the parameters of the von Bertalanffy growth equation using the backcalculated mean-lengths, rather than those obtained from the age-length keys.

Differences in length-weight regressions by sex are slight. The prediction equation for both sexes combined, was :

$$W = 0.0124\, L^{3.1373} \text{ or } \log W = 3.1373 \log L - 1.9063$$

Table VI : Growth in weight of *P. bogaraveo* by direct (otolith reading) and indirect (backcalculation) methods. (*) = von Bertalanffly equation.

	Direct method				Indirect method			
	N	W observed	95 % conf. limits	W (*) calculated	N	W observed	95 % conf. limits	W (*) calculated
1	6	65.7	37.1- 94.2	61.8	6	21.0	18.8- 23.2	24.4
2	68	153.0	141.0- 164.5	146.9	68	78.0	73.6- 82.4	70.1
3	127	267.5	254.2- 281.6	270.3	127	154.7	148.3- 161.1	143.9
4	128	379.7	384.4- 395.2	427.2	128	249.9	232.4- 267.4	245.2
5	76	540.9	514.3- 567.4	610.9	72	356.5	322.6- 390.4	370.9
6	57	697.4	662.0- 732.7	814.1	41	506.8	471.2- 542.4	517.0
7	46	834.5	799.9- 870.0	1029.9	21	659.4	627.1- 691.9	678.8
8	48	990.6	942.9- 1038.4	1252.0	20	838.3	805.6- 871.0	851.8
9	30	1215.4	1101.9- 1328.8	1475.2	18	1023.7	948.4- 1099.0	1032.0
10	29	1341.3	1244.5- 1438.1	1695.3	13	1218.2	1155.4- 1281.0	1215.6
11	17	1620.2	1465.6- 1774.9	1909.0	11	1411.8	1341.0- 1482.6	1399.4
12	12	1729.1	1452.7- 2005.5	2113.9	9	1601.4	1598.2- 1604.8	1580.9
13	10	1903.1	1505.5- 2300.6	2308.4	5	1786.7	1762.1- 1811.3	1758.1
14	4	2182.5	1153.7- 3211.3	2491.4	3	1988.8		1929.3

(*) von Bertalanffy equation

Table VII : Growth parameters of *P. bogaraveo* according to various authors. * = changed TL to FL to compare with other authors.

							Validity	
	Methods	to (years)	K	L_∞ (cm)	W_∞ (g)	v	L (cm)	Age (years)
Sanchez (1983)	direct otoliths	-1.55	0.117	58.50	4339.7	3.137	15.1-49.0	1-14
	indirect otoliths	-1.13	0.102	57.45	4101.4	3.137	11.2-45.2	1-14
	indirect otoliths	-0.53	0.209	45.86*	2042.6	3.079	12.1-43.8*	1-12
Gueguen (1969)	direct scales	-2.92	0.092	56.80	2628.0	3.137	17.2-49.9	1-20
Ramos *et al.* (1967)	direct otoliths	-1.02	0.128	53.86	-	-	18.1-44.5	2-12
Coupé (1954)	indirect scales	-	-	-	-	-	9.8-41.0	1-12
Olivier (1928)	direct scales	-	-	-	-	-	14.2-46.0	3-16

* changed TL to FL to compare with other authors

This equation compares favorably, with the one obtained by Gueguen (1969) who derived log W = 3.137 log L - 2.0862 and the other one obtained by Sanchez (1983) log W = 3.079 log L - 1.9586 for the same species.

P. bogaraveo is a slow-growing species but, beyond that it shows regional differences in growth which quite obviously depend on the area of descendance (Table VII). According to Sanchez (1983), the maximum length of blackspot seabream in the North Western Atlantic

Gueguen (1969) and Ramos *et al.* (1967) are 56.8 cm and 53.86 cm respectively in the bay of Biscay and in the Cantabrian Sea.

Comparing single age-groups, we see that e.g. 12 year-old blackspot seabream in Azorean waters and in Bay of Biscay are 42.4 cm in length, in Cantabrian Sea 44.5 cm, in North western Atlantic waters 43.8 cm and in Marrocco area 41 cm (Coupé, 1954). On the whole, there is a fairly good agreement between Azorean results, from age 9 until age 14, and those obtained by Gueguen (1969) in Bay of Biscay.

Comparing the growth coeficient (k) (Table VII), *P. bogaraveo* in Azores indicates a slower growth rate than that reported by Sanchez (1983), but similar to those presented by Gueguen (1969) and Ramos *et al.* (1967).

From an analysis of the length frequency distribution, Sanchez (1983) found the maximum age to be 10 years, whereas Ramos *et al.* (1967) and Coupé (1954) found a maximum age of 12 years from otoliths and scales, respectively. Olivier (1928) and Gueguen (1969) used direct reading on scales and reported 16 and 20 years respectively. In Azorean waters, a maximum age of 15 years was determined for a 49 cm-length fish.

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